# Engineering Feasibility Study

of

# Dredging and Disposal of Highly Contaminated Sediment-Acushnet River Estuary Above Coggeshall Street Bridge, New Bedford Superfund Site, Massachusetts

FINAL PROPOSAL

September 1985

Prepared by: U.S. Army Corps of Engineers
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ENGINEERING FEASIBILITY STUDY OF DREDGING AND DISPOSAL OF HIGHLY CONTAMINATED SEDIMENTS, ACUSHNET RIVER ESTUARY ABOVE COGGESHALL STREET BRIDGE, NEW BEDFORD SUPERFUND SITE

GENERAL

1. The U.S. Army Corps of Engineers (USACE) has been tasked by the Environmental Protection Agency (EPA) with additional predesign studies for the New Bedford Superfund Site. The purposes of these studies will be to develop technical information and to evaluate the engineering feasibility of various dredging and disposal alternatives for the Upper Harbor Area. The Omaha District (MRO) has been requested to provide coordination and management support for these studies. The New England Division (NED) and Waterways Experiment Station (WES) will cooperatively conduct the technical evaluation identified in this proposal. The Water Resources Support Center Dredging Division (WRSC-D) will provide technical support to assure the accuracy of the study evaluations.

Because this effort is only part of the entire Feasibility Study for New Bedford Harbor, emphasis on coordination of the tasks identified in this proposal with the many other ongoing and planned efforts is paramount. By active and continued coordination between the USACE, EPA, The Department of Justice, the National Oceanic and Atmospheric Administration, the Commonwealth of Massachusetts and study contractors, duplications of efforts can be minimized and schedules can be met.

The technical approach to the testing and evaluation of the dredging and disposal of highly contaminated sediments in the upper estuary will be consistent with the USACE management strategy for the disposal of dredged material.*

The "Management Strategy" is based on findings of research conducted by the USACE, the EPA and others over the past ten years, and on experience world wide in managing dredged MATERIAL disposal. It consists of a "suite of tests" developed specifically for the unique nature of dredged material, that when applied to the New Bedford Harbor sediments will allow for site specific evaluation of the available disposal alternatives. Thus, this proposal represents an application of the "Management Strategy" to the New Bedford Superfund Study with appropriate modifications.

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*Francingues, N. R., Jr., et al. 1985. "Management Strategy for Disposal of Dredged Material: Contaminant Testing and Controls," Miscellaneous Paper D-85-1, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

## OBJECTIVES

2. The objectives of this work are:

a. to develop a baseline characterization of the Upper Harbor Area with the degree of detail needed to (1) assess the engineering feasibility of the proposed dredging and disposal alternatives and (2) subsequent pre-design/design studies.

b. to assess the magnitude and migration potential of contaminant releases due to resuspension of sediments before, during and after proposed dredging operations.

c. to perform laboratory and bench scale testing developed specifically for dredged material to develop required technical data needed to predict the behavior of the New Bedford Harbor sediments if placed in the various disposal environments under consideration; and

d. to combine the technically feasible dredging and disposal technologies to provide an implementable alternative(s) and to provide concept design cost estimates for each implementable alternative.

## SCOPE OF WORK

3. The proposed study will provide an evaluation of the dredging and disposal alternatives from both an engineering and cost analysis view point but it will not develop a preferred alternative. A number of dredging and disposal options will be evaluated and technically feasible conceptual alternatives presented. Analysis of the environmental (biological, etc.), impact of these options is outside the scope of this proposal; these studies will provide additional information for EPA's environmental analysis. Only on site contained aquatic disposal and confined disposal in the adjacent upland and intertidal environments, as identified in the original feasibility study will be investigated. The USACE will:

a. gather data to establish permanent control points in the study area and to develop a base map for use in referencing existing and future work efforts to include subsequent pre-design and design studies;

b. perform sediment sampling and analysis for determining appropriate compositing of samples for testing and to determine the approximate limit of the dredging project (area and depth). Integretated physical and chemical data are needed to develop the compositing strategy for development of dredging and disposal options.

c. conduct limited geotechnical investigations to provide preliminary physical data on dredging and disposal site conditions for suitability of disposal areas and evaluations of concept designs.

d. define the conditions for contaminant migration to include hydraulic characteristics of the Upper Harbor area, sediment/bed interaction characteristics (deposition and resuspension tests), the long-term fate of material transported within study area, and the control of the dredging operation required to minimize its impact on spreading of contaminated sediments to other areas of the harbor.

e. perform a suite of tests on a composited sediment(s) deemed to be representative of the material that will be dredged and ultimately disposed. The sediment testing is designed to provide technical data needed for subsequent analyses of the engineering feasibility of the dredging and disposal alternatives and for EPA's assessment of any environmental impacts.

f. formulate a number of technically feasible dredging and disposal alternatives including a description of each alternative, a determination of engineering implementability and costs for implementation and construction.

g. prepare a final report detailing all work efforts performed, including all of the data acquired, testing performed, reference materials relied upon, and all analyses and information used to develop the alternatives available.

## ASSUMPTIONS

4. The contents of this proposal are based on but not limited to the following:

a. The latest USACE understanding of project goals, needs, and data bases available for this project provided by EPA and their contractors;

b. The USACE will provide this proposal as a comprehensive package that addresses only the engineering and cost analysis (not environmental) of the dredging and disposal alternatives identified as being appropriate for the Upper Harbor Area; no other alternative identified in the Feasibility Report (i.e., Hydraulic Control) will be directly evaluated for engineering feasibility. However, the EPA will be responsible for evaluating the (biological) impacts as additional information is generated through these studies as well as other on-going studies. The non-dredging alternatives identified in the feasibility report (i.e., no action, hydraulic control) will be evaluated by EPA in the focused Feasibility Study.

c. The sediment sampling and analysis strategy as proposed will sufficiently characterize the material to allow for subsequent sample compositing and testing. Any significant modifications or changes to the proposed approach will require re-evaluation of the study schedule and cost estimate;

d. The dates identified in Table 1 of this proposal are based on a notice to proceed on 1 August 1985. Field work will commence 1 September 1985. All field work is scheduled to be completed during the fall before inclement weather sets in. The study schedule provides for constant coordination and therefore the time required for review at critical milestone dates is assumed to be minimal.

e. Special care and handling of materials are required during all field and laboratory efforts. A site specific safety plan will be required and will be coordinated with MRD prior to initiation of the sampling program;

f. A quality assurance program will be required and will include a provision for chain-of-custody to assure legal integrity of the data;

g. The material collected and subsequently analyzed will be archived and properly disposed of when it is no longer needed.

h. The USACE management strategy for disposal of dredged material is applicable to the testing and evaluation of the highly contaminated sediments associated with the Upper Harbor area. The management strategy will provide the technical basis for testing and evaluating the available dredged material disposal alternatives.

## APPROACH

5. The work is organized into the following tasks and elements.

a. Task 1. Baseline Maps and Controls. The development of a baseline map is an essential first step in organizing and presenting existing and additional data collected on site. Review of the available data will also be required prior to initiation of any field work.

(1). Element 1. Establish Controls. The first step will be establishment of permanent vertical and horizontal control points in the area. All new field data collection will be referenced to these control points so subsequent work can locate the sample position.

(2). Element 2. Hydrographic Survey. A hydrographic survey of the entire river bottom will be provided at 100 foot cross sections from the Coggeshall Street Bridge.

(3). Element 3. Topographic Survey. Aerial photogrammetry will be used to complete the base map for the adjacent wetland and upland areas.

(4). Element 4. Sample Positioning. Sample locations will be documented for all field sampling and testing activities. Positions will be determined by Electronic Distance Measuring (EDM) and will be shown on the base map.

b. Task 2. Sediment Characterization.

A review of the existing physical and chemical data on the study area showed that there were insufficient data on the physical classification of sediments and distribution of contaminants to determine technical feasibility of the dredging and disposal alternative. The physical nature of the material to be dredged (e.g., consolidated versus loose) is needed to properly assess the technical feasibility of various dredging techniques. The horizontal and vertical distributions of contaminants and sediment types are important in the overall assessment of contaminant migration and sediment removal operations.

This information is also required to establish the total volume of material to be dredged and subsequent determination of the compatability of proposed dredging and disposal operations.

(1) Element 1. Sediment Sampling (Push Cores). Sample locations will be randomly chosen from within the predetermined 250 foot sampling grid. There will be approximately 180 sample locations throughout the Upper Acushnet Estuary and in associated wetlands. Thirty (30) of these locations will be located in adjacent wetland areas and will be accessed by land. The remaining 150 locations will be in the estuary proper and will require access by boat. Acrylic sample tubes (three inches in diameters and eight feet in length) will be pushed to refusal (8' maximum) at each location. After refusal to manual insertion is reached, some form of mechanically assisted insertion (e.g., driving) will be attempted to maximize penetration (8 foot minimum).

After each sample tube is removed from the water, a small hole will be drilled at the sediment-water interface, and the excess water will be allowed to escape. The excess tube will be cut off at the top of the sediment core, and the resultant core will be capped and sealed at both ends.

Sample cores will be labeled in the field with the sample location, date, time, collector, log number, and depth of refusal. Chain-of-custody documents will be initiated at that point and will be kept according to the protocol established in the QA/QC Plan. Samples will be transported and stored in an upright position and in refrigerated condition.

(2) Element 2. Vibracores for Chemical Samples. Eight locations will be chosen within the area to preliminarily determine the physical properties of the underlying material. If additional sampling capability deeper than that achieved by push cores is needed, this material will be available for subsequent chemical testing. No funds have been included to perform this additional chemical testing.

(3) Element 3. Quality Assurance/Quality Control (QA/QC) Plan. The QA/QC Plan will encompass both field and laboratory activities and will specifically include site sampling methods, chemical analysis methods, and chain-of-custody procedures. This plan will be developed by NED's Laboratory with assistance from the Missouri River Division Laboratory and the Waterways Experiment Station Environmental Laboratory. The QA/QC Plan will be designed to ensure the legal defensibility of the data and will be submitted to EPA and DOJ for review. The USACE will be responsible for data validation.

(4) Element 4. Site Specific Safety Plan. A site specific safety plan (SSSP) is required for all superfund site activities. The Missouri River Division will develop the SSSP with assistance from NED and WES. The SSSP will be implemented by NED during all phases of onsite work to assure proper protection and health of all personnel potentially exposed to any hazardous material.

(5) Element 5. Physical Tests. Physical tests will be performed on each visually district sediment layer for 30 stations selected from the original 180 locations. Physical tests to be performed will be the following:

(a) moisture content

(b) Atterberg limits
(c) grain size
(d) specific gravity
(e) organic solids
(f) Cation Exchange Capacity (CEC)

(6) Element 6. Chemical Analysis. Chemical analyses will be performed on a sample from the 2'-3' stratum (or other as desired) of each of 30 cores. If refusal was encountered prior to the 3' depth, analysis will begin with the lower foot of sediment in the tube. These core locations will be at the same locations as those chosen for the physical tests, above. Chemical analyses to be performed will be the following:

a) PCB's (Soxhlet extraction with GC/ECD)
b) Oil & Grease (Soxhlet extraction with IR)
c) Arsenic (Pyrosulfate digestion with hydride generation AAS)
d) Mercury (classic cold vapor AAS)
e) Trace Metals - Cadmium, Chromium, Copper, Lead, Nickel, and Zinc (nitric acid/peroxide digestion with flame AAS)

After the initial 2'-3' (or other) layer is analyzed, one additional sample will be analyzed from each core. If the 2'-3' layer is relatively "clean" (<1-2 ppm PCB's) in a particular core, then the next higher layer (1'-2') will be analyzed in the second round of analyses. Conversely, if the 2'-3' layer is contaminated then a sample from the 3'-4' layer will be analyzed. If the second layer (3'-4') is still contaminated, an additional, deeper layer (4'-5') will be analyzed, etc., until clean material is discovered in each of the 30 tubes. It is estimated that the third and subsequent rounds, if necessary, will involve the analysis of no more than twenty (20) additional samples.

The remaining 120 sample cores will be held for further chemical or physical analyses as needed to fill in data gaps.

If contaminated material is still encountered at the bottom of any particular tube, then an additional sample will be taken from the same location at a later date. The additional sample will be taken via the use of a sampling technique which will allow deeper penetration than that allowed by the push cores (e.g., "vibracore", or mechanical drilling). No funds have been included in this proposal cost estimate to obtain the additional samples.

(7) Element 7. Report of Chemical and Physical Tests. Data will be reported in typewritten, tabular form, and will include all information generated as a result of this work. All QA/QC data generated will be presented, and will be statistically analyzed as appropriate. Field and laboratory operations will be referenced and described.

c. Task 3. Geotechnical Investigation. The purpose of the geotechnical investigations is to provide preliminary physical data on site conditions for both the contained aquatic disposal and upland/intertidal disposal alternatives. This information will be used to assess the engineering feasibility of the proposed disposal options and will provide a basis for any additional investigations that may be needed for final design of a selected remedial action alternative.

(1) Element 1. Seismic Survey. Approximately 22,000 linear feet of seismic survey over water areas will be conducted to define the depth to bed rock and other identifiable sub-bottom materials.

(2) Element 2. Probs, Borings, Observation Wells and Vibracores. Approximately 585 linear feet of probes and 440 linear feet of borings on land and in the water will be made at the proposed containment areas to determine foundation conditions for the dikes. In addition, four 20-feet deep piezometers will be installed at the two proposed containment areas to assess groundwater conditions at the disposal site. Vibracore samples will be taken at 8 locations within the area to preliminarily determine the physical properties of the underlying material. The specific locations would be selected after review of the seismic survey. Additional vibracore samples needed for chemical characterization of the area were discussed previously under Element 2, Task 2. Physical testing of samples will be similar to the physical testing performed under Task 2, Element 5, and will be performed on the 5'-10' depth composite samples for the 8 samples. After review of all data collected, tests will be performed on critical strata to preliminarily assess site conditions for locating alternatives.

(3) Element 3. Geotechnical Report. A draft report will be prepared to present an analysis of the data obtained in the geotechnical investigation. This report will be included as part of the final report.

d. Task 4. Contaminant Migration Studies. Contaminant migration from the hot spot area, through Coggeshall St. Bridge, will be addressed by this task; potential for contaminant migration during both present conditions and during dredging will be studied.

The objectives of this task are to answer the following:

a. What are the concentrations of contaminants which will be released during the dredging operation due to sediment resuspension (soluble, particle associated, and oils fractions)?

b. Of the contaminants potentially released during dredging activities, what are the concentrations of contaminants in the water at the dredge head, at certain radii beyond the dredge site, and farther away from the dredge site, which will migrate out of the upper harbor?

c. What are the baseline present conditions in the upper harbor with regard to the movements and migration of contaminants and sediments out of the upper harbor?

d. What contributions do hydrologic and meterologic events make to the migration of contaminants out of the upper harbor, and how do they compare to those created by dredging activity?

e. After cleanup dredging, what will be the response of the remaining sediments to the new harbor configuration?

The problem of evaluating the migration of contaminants requires information on the sediment resuspended, the ambient currents and circulations, sediment characteristics, and the behavior of sediments (with their associated contaminants) in the system. The elements to follow are designed to provide this information and are interdependent to the overall objectives of this task.

(1) Element 1. Testing for Contaminant Release. A series of laboratory tests will be performed to determine the concentrations of contaminants released due to sediment resuspension during the dredging operation. These tests will consist of a series of elutriations and fractionations to define the contaminant concentrations associated with the dissolved or soluble fraction, oil fraction (potentially manifested in an oil shean), and particle-associated fractions corresponding to perhaps three ranges of particle grain size. Elutriate testing will be performed to define the potential for release in the soluble fraction and in the form of a floating oil sheen or scum. Fractionaction will be achieved by sequential centrifugation for purposes of defining particle-associated fractions. This testing approach has not been a routinely applied protocol, but the testing concepts are well documented and represent a modification of contaminants release testing to address the site specific problems of the New Bedford Superfund project. These tests will be conducted on composite samples representative of several reaches of the upper river of varying levels of contamination.

(2) Element 2. Controls for Dredging. The purpose of this element is to define the control of the dredging operations needed to minimize its impact on the spreading of contaminated sediments to the other areas of the harbor by means of sediment transport during dredging. The plan will be logically divided into first minimizing sediment resuspension during dredging and secondly, to controlling the impact of the resuspended sediment. This element will be a joint effort of the WES and NED.

(a) Dredge Controls. A determination of the optimum performance of dredge(s) in terms of low levels of sediment resuspension will be made. Emphasis will be on specific options in equipment, methodology, and implementation scenarios that have been demonstrated as highly effective for minimizing sediment resuspension.

(b) Turbidity Containment. The impact of the levels of sediment that are resuspended can be minimized through measures to keep the suspended sediment plume from being entrained into the main flow channels of the harbor. These measures, including the proposed sheet-pile weir and silt curtains, will be evaluated conceptually in this element, and technically by incorporation of plans into the sediment migration study element.

(3) Element 3. Hydraulic Characteristics. The objective of this task is to define the hydraulic characteristics in the upper harbor for both present conditions and dredging alternatives. This information will include current speeds and directions, water surface elevations, salinity distribution and identification of the significance of meteorological events. Knowledge of the currents is necessary to evaluate the transport, resuspension, and erosion of PCB-contaminated sediments under present conditions, for dredging alternatives and for the confined aquatic disposal option. The recommended technical approach is to first complete a desk analysis of the hydraulic characteristics of the harbor and then extend those findings to include a schematic two-dimensional modeling. Results will be used by Element 5 to model contaminant migration.

(a) Desk Study. A compilation of the readily available hydraulic data that has been collected by the participating agencies, followed by a desk analysis of that data will comprise the first step of this task. The simple analysis will address the suitability of the present data base for definition of the hydraulic characteristics for the feasibility study. The desk analysis will include the design of additional field data collection.

(b) Field Data Collection. Three field surveys will be conducted for purposes of evaluating the contaminant levels now being transported through the Coggeshall St. Bridge. This effort will serve as a refinement of the estimate made previously by the U. S. Coast Guard and EPA's Environmental Response Team. The data will also be used to calibrate the models for estimating contaminant migration during dredging, with controls, etc. Water column samples will be taken at the surface and a minimum of 3 subsurface depths at a minimum of 3 locations across the channel immediately above the bridge. Several locations in the Upper Harbor will also be sampled. These samples will be taken hourly during a full tidal cycle. All samples will be analyzed for suspended sediment concentration and grain size distribution. Flow conditions will be determined at the sampling locations and at additional stations as deemed necessary. Selected samples will be composited for analysis of PCB corresponding to the various fractions of interest. The contaminant flux will be characterized to include soluble, oils, and several grainsize fractions. Three tide gages will be installed to monitor water surface fluctuations during the studies.

(c) 2-D Schematic Modeling. Based on the hydraulic characteristics defined from the field data, numerical modeling work will be performed in two dimensions. If the field data reveal significant vertical density effects, then a 2-D vertical model would be applied. In the absence of significant vertical density phenomena, a 2-D horizontal model would be applied. These models would be verified to a limited extent, and then applied to give insights into the hydraulics of the system. The spatial extent of the numerical models would cover the zone of the harbor from Tarkin Hill Road to below the Interstate 195 bridge as needed to have fully developed inertial effects at the bridge on incoming tidal currents.

(4) Element 4. Deposition and Resuspension Tests. The purpose of this element is to define the sediment/bed interaction characteristics for use in other elements. The erosional and depositional properties of sediments vary and are of utmost importance to the prediction of sediment migration. Critical shear stresses for erosion and deposition, as well as erosion and deposition rates will be studied. The cost of the deposition and resuspension tests will depend on the level of special handling required for the material.

(a) Modification of Flume Procedures. The first step in undertaking the testing of such highly contaminated material is to modify the flume tests to ensure safety. This modification will be completed prior to initiation of material handling. The design will be accomplished through coordination with WES and any other concerned agency. A written laboratory safety plan will prepared to address material handling prior to, during, and after testing. The design must include filtration devices to recollect the material from suspension in flume waters, disposal of filters and other contaminated equipment, as well as decontamination of nondisposable equipment (e.g., flume itself).

(b) Material. It is anticipated that the flume tests will be conducted using one composited bottom sediment sample as described in Task 5. The level of contamination of the sediments to be tested will affect the cost of these tests. If sediment characteristics indicate a significant variation in materials, the composite sample will be fractionated and approximately five fractions tested.

(c) Deposition Testing. The testing will consist of mixing various concentrations of suspended sediments and introducing these into the flume. The steady-state flow rate of the flume will be operated over a range of shear stresses. During each test, the deposition will be measured, and based on the duration of the test, converted to a deposition rate. Grab samples from the flume will be tested in quiescent settling tubes. Graphical presentation of the data will define critical shear stresses for a number of sediment fractions.

(d) Erosion Testing. Erosion tests consist of first depositing a layer of material in the bottom of the flume and allowing it to consolidate. Then the flume will be operated at steady-state flows to cover a range of shear stresses. The suspended sediment concentration of the water in the flume will be monitored and at the end of the test, the erosion is measured and converted to an erosion rate. Graphical presentation of the test results will define the critical shear stresses for a number of sediment fractions.

(5) Element 5. Sediment Migration Analysis. This element will combine information from other elements to predict contaminant movements in and flux out of the upper harbor for no action, during dredging, and after completion of dredging. The technical approach is divided into near field, and system transport analyses.

(a) Near Field Dispersal. Predictions will be made of the dilution and settling of contaminated material resuspended by the dredgehead and swept from the dredging site by ambient currents and/or density effects. A multiple component numerical plume model and results from Elements 1-3 will be used for this work. This analysis will answer questions concerning the extent of local water quality degradation during dredging. The direction and concentrations of suspended contaminants will be provided for a number of dredge sites and ambient conditions representing worst cases. A much larger set of results will be used as input to the contaminant migration modeling.

(b) Contaminant Transport. A 2-D sediment-associated contaminant-transport model for the system will be developed. It will be compatible with and cover the upper harbor and adjoining areas with the same resolution as the hydroynamics modeling of Element 2. Information from Elements 2 and 3 and the near field dispersal model will be used by the sediment transport model. A number of sediment and contaminant fractions will be modeled. It will be assumed that contaminants are fixed to certain sediments (no adsorption or desorption will be simulated). Contaminant fractions will be given the same properties and characteristics as the sediments to which they are attached. Information from other tasks will establish the distributions of various sediment and contaminant fractions.

The sediment-contaminant model will be verified to observed fluxes of contaminants and sediments from the upper harbor defined from the field effort. Model predictions will then be made for a range of river inflows, tidal, and meteorologic conditions. Results will be statistically assembled into a representative annual contaminant flux.

A minimum of two dredging scenarios (upstream and downstream dredging) and as many as five dredging scenarios will be tested. If more dredging scenarios are determined to be necessary, additional funding and time to make these runs will be required. Approximately five dredging zones will be considered. Near field calculations of contaminant concentration and spread will be merged with the transport model dynamically. Effluent releases from containment areas will also be included in the simulations. A determintion of appropriate flow and tidal conditions will be made prior to evaluating the dredging scenarios using base test results. Contaminant fluxes from the upper harbor will be calculated.

Model simulations of the dredged harbor will be made in the same manner as for baseline conditions. The effect of dredging on the movements and migration of sediment and remaining contaminants over a range of condition will be tested. An annual flux of contaminant from the upper harbor will be calculated.

e. Task 5. Composite Sample for Testing. Sediment will be collected by NED from the area to be dredged above the Coggeshall Street Bridge using appropriate techniques, carefully homogenized, and transported to the WES where it will be subsequently distributed for testing. This sample would be composited from throughout the area. The composite sample would be designed from information resulting from previous and on-going characterization studies.

A key assumption has been made in the proposal that one composite sample will be representative of the material that will be dredged and disposed of. The dredging operation tends to mix the sediments sufficiently to dampen any extreme peaks in contaminant concentrations; however, if the sediment to be dredged is extremely heterogeneous (i.e., physically different material) then a revised testing scheme will be required and more than one composite sample may have to be prepared for testing. (No costs have been provided in this proposal to accomplish this task, if required).

Twenty-five new, steam-washed steel 55-gal drums, with lids and seals (lids are to be bolted and closed), will be filled from numerous locations in the area by means of a large box corer. Once filled the 25 drums containing New Bedford Harbor sediment will be poured into a clean concrete mixer, homogenized, and repoured in to the drums. The 25 homogenized drums will be loaded into a refrigerated (4 degrees centigrade) truck, transported to WES, then distributed for the various tests.

One (1) drum of material will be collected by a vibra core sampler from the area at 5' to 10' depth containing sediment proposed for use as a capping material. The drum will be labeled to distinguish it from those containing contaminated sediment.

Samples of water taken from near-bottom at the dredging site and identified disposal sites will also be taken and shipped to WES. Appropriate preservation and chain-of-custody techniques will be used throughout all phases of sample collection, mixing, distribution, and storage.

f. Task 6. Disposal Alternatives Composite Sample Testing. All of the elements identified in this task will be carried out by the WES in Vicksburg, Mississippi. The suite of tests that will be performed is consistent with the USACE technical approach to the testing and evaluation of contaminated dredged material to identify proper disposal alternatives. A description of specific tests to be conducted follows. Many of the test results are applicable to both the upland and intertidal (wetland) alternatives since they are both forms of confined disposal. However, the geochemical environment is different and some tests (e.g., the leachate) require additional runs for both environments.

(1) Element 1. Bulk Sediment and Water Chemistry. The composited, representative sediment and water samples will be analyzed to establish background reference for evaluation with results of the various tests. Both the dredging site and receiving water samples will be analyzed for dissolved and total contaminant concentrations. The sediment will be analyzed for total concentrations only. A priority pollutant scan will be run on the composited sediment sample. It is assumed that a list of select representative compounds or specific compounds of concern can be developed for the study through consultation with all involved agencies. As a rule, each of the tests will involve analysis of the same list of compounds. In addition to the parameters listed in Task 2, Element 6, the composite sample will be analyzed for cation exchange capacity (CEC), sodium adsorption ratio (SAR), and percentage of organics.

(2) Element 2. Modified Elutriate Tests. Modified elutriate tests are required to predict the quality of water discharged as effluent during active disposal operations. These tests define the dissolved and particle-associated concentration of contaminants in the effluent and account for the settling behavior of the dredged material, retention time of the containment area, and chemical environment in ponded water during active disposal. Data analyses from these tests rely on the determination of contaminant concentration in dredging site and receiving water samples as described in Element 1. Data analyses for prediction of total concentrations of contaminants in the effluent rely on results of the settling tests.

(3) Element 3. Surface Runoff Tests. The purpose of this element is to predict surface runoff water quality from a confined dredged material disposal site. When sediment is taken from the aquatic environment and placed in an upland condition, dramatic physicochemical changes can occur. As the sediment dries and oxidizes, the pH may drop from 8.0 to below 5.0 when large amounts of sulfides are present and some contaminants such as heavy metals may become very soluble in surface runoff. Decisions on disposal site selection and containment measures require information on the effects of these physicochemical changes on rainfall runoff water quality. The WES has developed a laboratory rainfall simulator-lysimeter system that can predict the surface runoff water quality from a confined upland dredged material disposal site prior to dredging and disposal of the material.

A soil lysimeter (15' x 4') will be filled with 11 drums of the composited sediment sample. A series of 6 rainfall simulations will be conducted with the lysimeter during the drying process. Three simulations will be conducted while the sediment is wet and relatively unoxidized, and 3 additional simulations will be conducted after sediment has dried to below 10% moisture and the sediment pH has stabilized. Each storm event will be 2 inches/hour for 0.5 hours. Runoff rates will be measured and samples will be collected throughout the storm events. A representative composite sample will be made for each run and will be divided into filtered and unfiltered portions. Each sample along with 2 rain water samples will be analyzed for the appropriate list of chemical compounds.

The data will be compiled and analyzed to provide runoff contaminant loads and concentrations to be expected from a confined disposal site filled with this material. A Memorandum for Record will be provided as soon as possible to expedite the distribution of study results and an interpretative summary will be provided as the final product.

(4) Element 4. Leachate Prediction Tests. When contaminated dredged material is placed in a confined disposal facility, the potential exists for adverse leachate impacts on groundwater and surface water quality. Subsurface drainage and seepage through dikes may reach adjacent surface and ground waters, resulting in deterioration of surface water quality and contamination of groundwater aquifers.

At present, there is no routinely applied laboratory testing protocol capable of predicting leachate quality from confined dredged material disposal sites. However, a predictive protocol for leachate quality in confined disposal facilities is the objective of a current research effort at WES. The protocol in its current state of development involves both experimental leaching tests and procedures for extrapolating the laboratory leach data to the field situation using predictive equations. The series of laboratory tests recommended below are, therefore, developmental in nature.

The objective of the leachate prediction element is to apply appropriate testing procedures for estimating leachate contaminant levels and release rates from dredged material in a confined disposal facility. Specific items to be performed include the following:

(a) Batch leaching tests. Aerobic and anerobic sequential batch leaching tests will be conducted on the sediment. In sequential batch leaching tests, sediment is challenged by fresh leaching solution over time instead of being continually exposed to the same solution. These tests will allow identification of the critical factors influencing contaminant mobility and quantification of release rates under varying environmental conditions that may be encountered in a confined disposal facility. Leachate will be chemically analyzed for selected contaminants as indicated by the bulk chemical analysis as contaminants of concern. The batch leaching tests will provide desorption coefficients needed for the mass transfer equation used to predict contaminant mobility.

(b) Divided flow permeameter tests. Anaerobic and aerobic divided-flow permeameter leaching tests will be conducted to simulate field leaching processes. Permeameter testing will be used to verify the mass transfer equation and the generality of the desorption coefficients determined in the batch leaching tests.

(c) Data reduction and interpretation. Batch and permeameter data will be synthesized to provide an assessment of contaminant mobility in the dredged material. A one-dimensional, convective-dispersive mass transfer equation with a source term for contaminant leaching will be used to model leachate quality in the disposal site and to estimate contaminant flux at the dredged material/site bottom interface.

(5) Element 5. Contained Aquatic Disposal Capping Tests. One disposal option being considered for the Upper Harbor project is contained aquatic disposal (CAD). However, when contaminated dredged material is placed in open water and covered with a cap of clean sediment, the potential exists for contaminants to diffuse through the cap, if the cap thickness is inadequate. Alternatively, bioturbation by benthic fauna may breach the cap, resulting in direct contact of contaminated sediment with the water column and biota. Therefore, the objective of this element is to apply the predictive test for estimating the appropriate cap thickness required to chemically seal contaminated New Bedford Harbor sediment from the overlying water column in a CAD.

At present, the WES is developing a simplified predictive method for determining the appropriate cap thickness required to chemically seal contaminated sediment from the overlying water column. The tasks described below are intended to provide this information.

(a) Cap Thickness Evaluation. Predictive tests will be conducted to determine the appropriate cap thickness required to isolate the contaminated dredged material. These tests will be conducted using 22.6 liter, cylindrical plexiglass leaching column using selected chemical constituents as tracer compounds.

(b) Cap Thickness Verification. Small leaching columns will be loaded with the New Bedford Harbor sediment, than capped with the thickness of clean sediment identified as necessary in the above tests to chemically seal the contaminated sediment from the overlying water. The water in these columns will then be monitored for a small number of indicator compounds, such as PCB's, to give a limited verification of results obtained in the predictive tests. Water column analyses from the small columns containing capped sediment will then be compared with water analyses from identical columns containing either cap only or Upper Harbor sediment only.

(c) Data Reduction and Interpretation. Predictive and verification test data will be analyzed and compared to provide planning level assessments of the effectiveness of capping in sealing the contaminated New Bedford Harbor sediment from the overlying water column. Curves resulting from plots of cap thickness against contaminant appearance in the water column will be used to demonstrate required cap thickness. Recommendations will be made for additional cap thickness to provide adequate protection for the effects of bioturbation on cap integrity. These recommendations will be based on discussions with authorities on bioturbation in the New Bedford Harbor area.

(6) Element 6. Engineering Classification. The engineering characterization of the sediment is required in interpretation of data from both the settling and consolidation testing and in proper interpretation of results from chemical tests. The engineering characterization tests should include in-situ water content (determined from composited samples), grain size

analysis (both sieve and hydrometer), Atterberg limits, specific gravity, and organic content. These tests will allow the sediment to be classified according to the Unified Soil Classification System (USCS).

(7) Element 7. Settling Tests. Settling tests are required to define the sedimentation characteristics of the sediment to be dredged. These tests will determine the required disposal area ponding depth and surface area required for effective retention of suspended solids during the dredging operation and can be used to predict the concentration of suspended solids in the effluent resulting from gravity settling within the disposal area. The tests will be conducted using 8-inch diameter settling columns.

(8) Element 8. Chemical Clarification Tests. Jar tests (laboratory bench-scale tests) are required in designing systems for addition of chemical polymers for removing suspended solids from effluent or runoff which cannot be removed by gravity settling alone. A series of polymer screening tests will be conducted to select the specific chemical resulting in the optimum removal for the sediment in question. A separate series of tests is then conducted to determine the optimum dosage of chemical required and the mixing required under field conditions. Screening tests typically involve several classes of polymer and several samples of commercially available polymer in each class. Several dosages and mixing levels will be tested for the selected polymer to define the system design requirements.

(9) Element 9. Consolidation Tests. Consolidation tests are required to define the consolidation properties of the sediment to be dredged and to provide data on the potential flow of groundwater for the leachate evaluations. Consolidation tests are also needed to properly interpret monitoring data for the CAD alternative. Results of these tests are used as input for predictions of the storage capacity of the disposal areas. A large-strain, controlled-rate-of-strain testing device at WES will be used to conduct these tests. Void ratio-effective stress and void ratio-permeability relationships for the sediments are defined by these tests.

(10) Element 10. Liner Evaluation and Sediment Stabilization Tests. Because of the contaminated nature of the sediments, special precautions may be needed during dredging and disposal of the sediments. If the material is disposed in a confined site, a liner may be needed, depending on the quality and quantity of leachate generated, in order to protect groundwater and surface water resources. Interactions between chemical components in the leachate and the liner can result in liner deterioration. Liner selection should, therefore, be based on compatability with the leachate.

One promising technique for immobilizing contaminants, providing a liner, and improving the engineering properties of dredged material is solidification/stabilization. Solidification/stabilization involves the addition of a setting agent(s) to the dredged material. Various setting agents have been used to treat hazardous industrial wastes and flue gas desulfurization sludges. Additives include cement, lime, kiln dust, flyash, blast furnace slag, sodium and potassum silicates, and various combinations of these materials. The resulting product has improved engineering properties (lowered permeability and increased bearing capacity) and reduced contaminant mobility (leaching).

The work proposed includes laboratory liner compatability evaluations and laboratory investigations of innovative techniques for immobilizing contaminants in the dredged material. This work will be coupled with the work on prediction of leachate quality. Together, these studies should provide data on the compatability of various liner materials with dredged material leachate and on the ability of solidification/stabilization technologies to reduce contaminant mobility and to improve the engineering properties of dredged material. The study will be accomplished in the series of activities outlined below.

(a) A limited number of liner materials will be tested for compatability with leachate from New Bedford Harbor sediments. Leachate from divided-flow permeater leach testing will be used for this purpose. Natural and synthetic materials will be tested and evaluated. It is anticipated that the New England Division will identify and provide for testing a local clay, if available. The WES will identify synthetic materials for testing on the basis of known chemical and physical resistance to compatability data needed for liner selection.

(b) A limited number of stabilization techniques will be selected for investigation on the basis of previous work with dredged material, contaminated soils, and industrial sludges. Several commercial vendors of proprietary technologies will be invited to participate in the study on a non-reimbursable basis. Vendors will be asked to investigate the applicability of their processes to New Bedford sediments and to provide to the WES a recommended dosage of their additive(s). The WES will supplement the proprietary formulations with a public domain technology. A sorbent assisted solidification/stabilization technology that uses an absorbent to reduce chemical leachability will also be investigated.

(c) Samples of stabilized products will be prepared and cured for physical and chemical testing (d) and (e) below. Products to represent additive dosages below, at and above the recommended dosage will be used.

(d) Selected physical properties tests will be conducted on the products developed in (c). These include unconfined compressive strength, permeability, and specific gravity of the solids. In addition, the strength versus cure-time curve will be investigated using a resistance to penetration test (cone penetrometer). Unconfined compressive strength will also be measured at selected cure times in order to correlate the resistance to penetration curve to unconfined compressive strengh.

(e) Samples of solidified/stabilized dredged material will be subjected to laboratory leaching tests. The data from these tests will be used to assess the potential of contaminant release from the various products. This work will be coordinated with the WES research on mathematical modeling of contaminant leaching. Analysis of leachates will be limited to total PCB's, total organic carbon, and one or two selected metals.

(11) Element 11. Treatment Studies. Treatment for the confined disposal alternatives will be limited to site effluent. (The need to evaluate leachate and runoff treatment can only be addressed after the specific site controls have been selected and leachate prediction has been completed.) Therefore, the emphasis on treatment will be on removal of contaminants from the site

effluents during and post dredging operations.

Among the processes widely applied in confined disposal are sedimentation for solids and particulate-bound contaminant removal, and chemical clarification and filtration for enhanced removal of particulates (suspended solids), adsorbed metals and adsorbed organics. Use of activated carbon for removal of soluble organics and some trace metals has received limited application to dredged material. (It should be noted here that treatment efficiencies for the processes mentioned will have to be obtained through material-specific testing, evaluations and potential pilot-scale testing before appropriate design and operating criteria could be specified). Therefore, the treatment work will initially be focused on the screening of various treatment processes for applicability and potential treatment capability. This screening will be based on results of laboratory and bench-scale testing. Such tests include: adsorption isotherms and small diameter breakthrough columns.

g. Task 7. Conceptual Dredging and Disposal Alternatives and Costs. This task will be performed jointly by the NED and the WES. The USACE will formulate a number of technically feasible dredging and disposal alternatives based on results of the previous tasks and the elements described under this task. There could be only one alternative or as many as five or six depending upon the test results. These conceptual alternatives will be developed to sufficient detail for costing and determining technical feasibility. Schematic plans, a cost estimate and a description of each alternative will be presented. The preferred dredging alternative analysis will not be performed by the USACE. The EPA will select the preferred alternative based on the results of these studies and the assessment of the potential environmental impacts of the feasible dredging and disposal alternatives.

(1) Element 1. Dredging Equipment Evaluations. Dredge methods and equipment will be reviewed including foreign technology and those with greatest potential for applicability to the New Bedford situation will be identified. Emphasis will be on specific options in equipment, methodology, and design that have been positively evaluated and demonstrated elsewhere. Hydraulic dredging has been identified by recent research as the conventional technique with the least potential for resuspension and release of contaminants. Operational practices such as cutter rotation, swing, depth of burial, etc., that will be examined in Task 4, Element 2, Controls for Dredging, will be used for this assessment. Results from planned demonstrations of innovative equipment at Indiana Harbor, Indiana will also be considered in the final selection of equipment and operational techniques.

(2) Element 2. Evaluation of Confined Sites (Upland/Intertidal). Evaluation of design requirements for confined sites will include:

(a) Determination of sizing requirements (i.e., surface area and volume) for the containment areas during disposal and engineering storage capacity requirements.

(b) Determination of requirements for chemical clarification (additional solids removal by flocculation).

(c) Determination of design concepts for a final effluent/leachate/run-off treatment system if required (e.g., filtration, activated carbon adsorption, synthetic adsorbers, etc.)

(d) Determination of containment area design features to minimize migration of contaminants following disposal (e.g., liners, covers, stabilization, etc.)

(3) Element 3. Evaluation of Contained Aquatic Disposal (CAD). Contaminated sediments disposed in subaqueous pits may be physically, chemically, and biologically isolated by covering them with a layer of capping material. The capping concept is simple and has been successfully employed in other areas of the United States as well as in Europe and Japan. CAD was identified by EPA's contractor as a technically feasible alternative in an addendum to The Feasibility Study.

Results of past capping demonstrations, research, and testing under this scope of work will be used to evaluate the technical feasibility of a confined aquatic disposal site for New Bedford material. Since accurate placement of both contaminated sediments and capping material is critical, promising equipment developments (e.g., submerged diffuser system) will be evaluated for compatibility with conventional dredging equipment and practices. Data collected on a demonstration of a submerged diffuser at Indiana Harbor, Indiana, will be considered in the evaluation.

h. Task 8. Draft and Final Reports. Due to the potentially critical scheduling of subsequent design and construction activities, dissemination of study results for interim decision-making will be desirable. Interim results of the study will be made available in the form of interpretive summaries, verbal briefings and Memoranda for Record as needed. A draft and final report will be prepared fully describing the results of the testing program.

i. Task 9. Coordination. The Omaha District (MRO) will assure proper coordination of the USACE work effort with the EPA. The Water Resources Support Center Dredging Division (WRSC-D) will provide technical review for both the NED and the WES tasks related to the dredging and disposal evaluation.

Additional time has been added to provide some coordination with all of the other studies that are involved in the New Bedford site. Working level meetings with all involved must be held at the outset and at critical points to integrate all activities and schedules.

Points of contact for this project will be:

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Primary: Mr. William Bonneau
Alternate: Mr. S. L. Carlock

(2) Water Resources Support Center Dredging Division
Primary: Mr. Dave Mathis
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(3) U.S. Army Engineer Waterways Experiment Station
Primary: Mr. Norman Francingues
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(4) New England Division
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## SCHEDULE AND COSTS

6. The schedule for accomplishing each task/element, the costs, and the USACE agency responsible for performing the task/element are shown in Table 1. A total of $1.614 million and approximately 18 months will be required to successfully complete the proposed study. This schedule assumes constant coordination and availability of funds at least one month in advance of proposed work starts.